

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY PCT

(Chapter II of the Patent Cooperation Treaty)

REC'D 17 FEB 2006

## (PCT Article 36 and Rule 70)

|   |   |  |                       |
|---|---|--|-----------------------|
| Applicant's or agent's file reference<br>XA1732   | <b>FOR FURTHER ACTION</b>   |  | See Form PCT/IPEA/416 |
| International application No.<br>PCT/GB2004/004674  | International filing date (day/month/year)<br>04.11.2004              | Priority date (day/month/year)<br>07.11.2003 |                       |
| International Patent Classification (IPC) or national classification and IPC<br>G01D5/14, G01V3/08  |   |  |                       |
| Applicant<br>BAE SYSTEMS PLC et al.   |   |  |                       |
| <p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 8 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> (<i>sent to the applicant and to the International Bureau</i>) a total of 3 sheets, as follows:</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</li> <li><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</li> </ul> <p>b. <input type="checkbox"/> (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p> |   |  |                       |
| <p>4. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> Box No. I Basis of the opinion</li> <li><input type="checkbox"/> Box No. II Priority</li> <li><input checked="" type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li><input type="checkbox"/> Box No. IV Lack of unity of invention</li> <li><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li><input type="checkbox"/> Box No. VI Certain documents cited</li> <li><input type="checkbox"/> Box No. VII Certain defects in the international application</li> <li><input type="checkbox"/> Box No. VIII Certain observations on the international application</li> </ul>  |   |  |                       |
| Date of submission of the demand<br>07.09.2005  | Date of completion of this report<br>20.02.2006                       |  |                       |
| Name and mailing address of the International preliminary examining authority:<br><br>European Patent Office - P.B. 5818 Patentlaan 2<br>NL-2280 HV Rijswijk - P.O. Box<br>Tel. +31 70 340 - 2040 Tx: 31 651 epo nl<br>Fax: +31 70 340 - 3016  | Authorized Officer<br><br>Chapple, I<br>Telephone No. +31 70 340-3511 |  |                       |



# INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/GB2004/004674

## Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
  - This report is based on translations from the original language into the following language, which is the language of a translation furnished for the purposes of:
    - international search (under Rules 12.3 and 23.1(b))
    - publication of the international application (under Rule 12.4)
    - international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

### Description, Pages

1-9 as originally filed

### Claims, Numbers

1-21 received on 16.12.2005 with letter of 16.12.2005

### Drawings, Sheets

1/3-3/3 as originally filed

a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3.  The amendments have resulted in the cancellation of:

- the description, pages
- the claims, Nos.
- the drawings, sheets/figs
- the sequence listing (*specify*):
- any table(s) related to sequence listing (*specify*):

4.  This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- the description, pages
- the claims, Nos.
- the drawings, sheets/figs
- the sequence listing (*specify*):
- any table(s) related to sequence listing (*specify*):

\* If item 4 applies, some or all of these sheets may be marked "superseded."

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**Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability**

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

the entire international application,

claims Nos. 15,21

because:

the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (specify):

the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (specify):

the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

no international search report has been established for the said claims Nos. 15,21

the nucleotide and/or amino acid sequence listing does not comply with the standard provided for in Annex C of the Administrative Instructions in that:

the written form

has not been furnished

does not comply with the standard

the computer readable form

has not been furnished

does not comply with the standard

the tables related to the nucleotide and/or amino acid sequence listing, if in computer readable form only, do not comply with the technical requirements provided for in Annex C-*bis* of the Administrative Instructions.

See separate sheet for further details

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**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

|                               |      |        |            |
|-------------------------------|------|--------|------------|
| Novelty (N)                   | Yes: | Claims | 1-14,16-20 |
|                               | No:  | Claims |            |
| Inventive step (IS)           | Yes: | Claims | 1-14,16-20 |
|                               | No:  | Claims |            |
| Industrial applicability (IA) | Yes: | Claims | 1-14,16-20 |
|                               | No:  | Claims |            |

**2. Citations and explanations (Rule 70.7):**

**see separate sheet**

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**1. Reference is made to the following documents:**

D1: US 2002/008513 A1 (DEWINTER RUDI ET AL) 24 January 2002 (2002-01-24)

D2: US-B1-6 292 758 (KOHNEN KIRK K ET AL) 18 September 2001 (2001-09-18)

D3: US 2002/050043 A1 (SARH BRANKO ET AL) 2 May 2002 (2002-05-02)

D4: EP-A-0 427 882 (ROBERT BOSCH GMBH) 22 May 1991 (1991-05-22)

**2. Clarity (Article 6 PCT)**

2.1 Attention is drawn to the fact that, under Article 6 PCT, the claims should be clear. As such, the claims should be understandable in their own right, and not only in light of the application when taken as a whole.

2.2 The use of the word **calibrator** in claim 1 is somewhat confusing; once in the positioning mode, there is no calibration being performed, only correction or compensation. A similar objection applies to the use of the word **calibrating** in claim 16. Again, when in the positioning mode, the first and second magnetic field sensing devices are not being **calibrated**, they are being corrected or compensated, on the basis of stored compensation values.

2.3 In the description (page 7, line 27 - page 8, line 31) there is no mention of the **mathematical model** being used when in the positioning mode. Therefore, the presence of a mathematical model in claims 1 and 16 is misleading.

The subject matter of claims 1 and 16 also make reference to the **mathematical model** determining a **predicted magnetic field** and that this predicted value is then **compared** with the **first and second measured magnetic fields**; once again, this is not described or implied anywhere on pages 7 and 8 of the description.

2.4 The phrase **estimator algorithm** in claims 1 and 16 is not clear, and results in claims 1 and 16 not meeting the requirements of Article 6 PCT in that the matter for which

protection is sought is not clearly defined. The claims attempt to define the subject-matter in terms of the result to be achieved, which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result.

**2.5** It is not clear from the description and the claims what the function of the **Kalman filter algorithm** is. In the description (page 7, line 27 - page 8, line 23) there are two alternative embodiments. The first uses the Kalman filter both as a calibrator and as an estimator; the second uses a separate calibrator algorithm and the Kalman filter as an estimator.

### **3. Inventive Step (Claim 1)**

**3.1** The aforementioned clarity objections notwithstanding, the subject matter of claim 1 is considered as involving an inventive step. The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and discloses (the references in parentheses applying to this document):

A position sensor (400, figure 4) for sensing the position of an object (600, figure 6) having an associated magnetic field having:

a first magnetic field sensing device (I, figure 4) at a first position that outputs a first signal related to the magnetic field at the first position;

a second magnetic field sensing device (II, figure 4) at a second position that outputs a second signal related to the magnetic field at the second position;

a processor (432, figure 4) to derive from the first signal and the second signal the most likely position of the position sensor relative to the object.

**3.2** The subject-matter of claim 1 therefore differs from this known D1 in that:

the processor comprises a calibrator to calibrate the first and second magnetic field sensing devices individually, thereby deriving first and second measured magnetic

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fields, a mathematical model to determine a predicted magnetic field at a given position relative to the object and an estimator algorithm to compare the predicted magnetic field with the first and second measured magnetic fields.

- 3.3** The subject matter of claim 1 is therefore new (Article 33(2) PCT).
- 3.4** The problem to be solved by the present invention may therefore be regarded as how to improve the precision of the position sensor.
- 3.5** Although D2 (see the claims) discloses the use of a Kalman filter to assist in the localisation of a magnetic field, it does not disclose the use of a calibrator or a mathematical model.

D3 discloses an apparatus for locating the position of a magnetic target through a wing skin; however, it does not disclose any of the features of claim 1 missing from D1.

D4 simply discloses a device for determining the position of a cylindrical target magnet with respect to a stationary array of sensors.

As any combination of D1 with D2, D3 or D4 would not disclose the subject matter of claim 1, the solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT).

**4. Inventive Step (Claim 16)**

The aforementioned clarity objections notwithstanding, the subject matter of claim 16 is also considered as involving an inventive step; the reasons are the same as those given for claim 1 in points **3.1-3.5**.

**5. Dependent Claims 2-14 and 17-20**

- 5.1** As claims 2-14 depend on claim 1, these are also considered as being both new and inventive, thereby fulfilling the requirements of Articles 33(3)-33(3) PCT.

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**5.2** As claims 17-20 all depend on claim 16, these are also considered as being both new and inventive, thereby fulfilling the requirements of Articles 33(3)-33(3) PCT.

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CLAIMS

1. A position sensor for sensing the position of an object having an associated magnetic field comprising:

5 a first magnetic field sensing device at a first position that outputs a first signal related to the magnetic field at the first position;

a second magnetic field sensing device at a second position that outputs a second signal related to the magnetic field at the second position;

10 a processor to derive from the first signal and the second signal the most likely position of the position sensor relative to the object, wherein the processor comprises:

a calibrator to calibrate the first and second magnetic field sensing devices individually, thereby deriving first and second measured magnetic fields;

15 a mathematical model to determine a predicted magnetic field at a given position relative to the object;

an estimator algorithm to compare the predicted magnetic field with the first and second measured magnetic fields, thereby calculating the most likely position of the position sensor relative to the object.

20 2. A position sensor as claimed in claim 1 wherein the first calibrator further comprises a correction model.

3. A position sensor according to claim 2 wherein the correction model comprises a gain term and an offset term.

25 4. A position sensor according to any preceding claim wherein the estimator algorithm comprises an extended Kalman Filter algorithm.

5. A position sensor according to any preceding claim wherein the processor continually derives the most likely position of the position sensor relative to the object in real time.

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6. A position sensor according to any preceding claim wherein during operation of the position sensor the object is separated from the position sensor by a wing skin.
7. A position sensor according to any preceding claim wherein, during operation of the first calibrator, the first magnetic field sensing device is at a known position relative to the object and is separated from the object by a wing skin of predetermined thickness.
- 5 8. A position sensor according to any preceding claim wherein the object comprises a cylindrical magnetic object.
- 10 9. A position sensor as claimed in any preceding claim wherein the magnetic field sensing devices comprise Hall Effect devices.
10. A position sensor according to any preceding claim wherein the estimator comprises a software program.
11. A position sensor according to any preceding claim wherein the first 15 calibrator comprises a software program.
12. A computer program executable to derive the most likely position of a position sensor according to any one of claims 1 to 9 in relation to the magnetic object.
13. A computer programmed to derive the most likely position of a position 20 sensor according to any one of claims 1 to 9 in relation to the magnetic object.
14. A portable device comprising a position sensor according to any of claims 1 to 9.
15. A position sensor substantially as described herein with reference to the 25 accompanying drawings.
16. A method of sensing the position of an object having an associated magnetic field using a position sensor comprising first and second magnetic field sensing devices at first and second positions  
the method comprising the steps of:

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- (a) sensing a first signal related to the magnetic field at the first position from the first magnetic field sensing device;
- (b) sensing a second signal related to the magnetic field at the second position from the second magnetic field sensing device;
- 5 (c) calibrating the first magnetic field sensing device, thereby deriving a first measured field from the first signal;
- (d) calibrating the second magnetic field sensing device, thereby deriving a second measured magnetic field from the second signal;
- (e) determining a predicted magnetic field at a given position relative to the object using a mathematical model;
- 10 (f) comparing the predicted magnetic field with the first and second measured magnetic fields using an estimator algorithm, thereby calculating the most likely position of the object relative to the position sensor.

15 17. A method as claimed in claim 16 wherein the step of calibrating the first magnetic field sensing device comprises using a correction model.

18. A method as claimed in claim 17 wherein the correction model comprises a gain term and an offset term.

19. A method as claimed in any of claims 16 - 18 wherein the estimator algorithm comprises an extended Kalman filter algorithm.

20 20. A method as claimed in any of claims 16 - 19 further comprising continually deriving the most likely position of the position sensor relative to the object in real time.

21. A method substantially as described herein with reference to the accompanying drawings.

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TOTAL P.08